# Motion Control

## 7324/7314
## Hardware User Manual

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**Worldwide Technical Support and Product Information**

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Digital electronics emit weak signals during normal operation that can affect radio, television, or other wireless products. By examining the product you purchased, you can determine the FCC Class and therefore which of the two FCC/DOC Warnings apply in the following sections. (Some products may not be labeled at all for FCC; if so, the reader should then assume these are Class A devices.)

FCC Class A products only display a simple warning statement of one paragraph in length regarding interference and undesired operation. Most of our products are FCC Class A. The FCC rules have restrictions regarding the locations where FCC Class A products can be operated.

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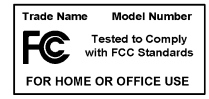


Consult the FCC web site `http://www.fcc.gov` for more information.

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This equipment generates and uses radio frequency energy and, if not installed and used in strict accordance with the instructions in this manual and the CE Mark Declaration of Conformity**, may cause interference to radio and television reception. Classification requirements are the same for the Federal Communications Commission (FCC) and the Canadian Department of Communications (DOC).

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### Class A

#### Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

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- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.

- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

### Canadian Department of Communications

This Class B digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

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* Certain exemptions may apply in the USA, see FCC Rules §15.103 **Exempted devices**, and §15.105(c). Also available in sections of CFR 47.

** The CE Mark Declaration of Conformity will contain important supplementary information and instructions for the user or installer.

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# About This Manual

This manual describes the electrical and mechanical aspects of each controller in the ValueMotion 7324/7314 family of controllers and contains information concerning their operation and programming. Unless otherwise noted, text applies to all controllers in the ValueMotion 7324/7314 family.

The 7324/7314 family includes the following motion controllers:

- ♦ Stepper (Open-Loop)
  - PCI-7314
  - PXI-7314
- ♦ Stepper (Closed-Loop)
  - PCI-7324
  - PXI-7324

The 7324/7314 stepper controllers are low-cost, high-performance controllers for PCI and PXI bus computers.

## Conventions

The following conventions appear in this manual:

<> Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, DBIO<3..0>.

♦ The ♦ symbol indicates that the following text applies only to a specific product, a specific operating system, or a specific software version.

This icon denotes a note, which alerts you to important information.

This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.

This icon denotes a warning, which advises you of precautions to take to avoid being electrically shocked.

| | |
|---|---|
| *italic* | Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text that is a placeholder for a word or value that you must supply. |
| $\overline{\text{overline}}$ | Indicates a signal is active-low. |
| 7324 controller | Refers to the ValueMotion PCI-7324 and the PXI-7324 closed-loop stepper controllers. |
| 7314 controller | Refers to the ValueMotion PCI-7314 and the PXI-7314 open-loop stepper controllers. |
| 7324/7314 controller | Refers to the ValueMotion PCI-7314, PXI-7314, PCI-7324, and PXI-7324 stepper controllers. |
| PCI controller | Refers to the PCI-7324 and the PCI-7314 controllers. |
| PXI controller | Refers to the PXI-7324 and the PXI-7314 controllers. |

# Related Documentation

The following documents contain information that you might find helpful as you read this manual:

- *ValueMotion Software Reference Manual*
- ValueMotion VI Online Help
- *PCI Local Bus Specification, Revision 2.1*
- Your computer's technical reference manual

# 1

# Introduction

This chapter describes the ValueMotion 7324/7314 controllers and their operation.

## About the 7324/7314 Controllers

Thank you for purchasing a National Instruments 7324/7314 motion controller. The 7324/7314 controllers are stepper motor controllers for PCI and PXI bus computers. These controllers provide fully programmable motion control for up to four independent axes of motors, with additional I/O for limit and home switches as well as other general-purpose functions. You can use these controllers in position or velocity control applications, with support for point-to-point position, velocity profiling, and event-based motion profiling modes.

The 7324 closed-loop controllers control stepper motors and can operate in open or closed-loop mode. They use quadrature encoders for position and velocity feedback, and clockwise (CW)/counter-clockwise (CCW) or step/direction digital outputs for command. The 7314 open-loop stepper controllers do not include the quadrature decoders and can operate only in open-loop mode. All controllers support full, half, and microstepping applications.

## What You Need to Get Started

To set up and use your 7324/7314 controller, you will need the following:

- ❑ One of the 7324/7314 controllers
- ❑ *7324/7314 Hardware User Manual*
- ❑ One of the following software packages and documentation:
  - LabVIEW
  - Measurement Studio
  - ValueMotion Software (includes pcRunner)
- ❑ Your computer with an available PCI or PXI slot, as appropriate

# Software Programming Choices

You have several options to choose from when programming your National Instruments 7324/7314 controllers. You can use National Instruments application software, ValueMotion VIs for LabVIEW, or ValueMotion software.

Programming the 7324/7314 controller is straightforward using a simple but powerful high-level function set application programming interface (API). All setup and motion control functions are easily executed by calling into either a static or dynamically linked library (DLL). These libraries are callable from C, Visual Basic, and other high-level languages. Full function set implementations are available for LabVIEW, Measurement Studio, and other industry-standard software programs.

# National Instruments Application Software

LabVIEW, based on the graphical programming language G, features interactive graphics and a state-of-the-art user interface. In LabVIEW, you can create 32-bit compiled programs and stand-alone executables for custom data acquisition, test, and measurement solutions. National Instruments offers the ValueMotion VI Library, a series of virtual instruments (VIs) for using LabVIEW with National Instruments motion control hardware. This VI library implements the full function set API and a powerful set of demo functions, example programs, and fully operational, high-level application routines.

ANSI C-based LabWindows/CVI also features interactive graphics and a state-of-the-art user interface. Using LabWindows/CVI, you can generate C code for custom data acquisition, test, and measurement solutions. The ValueMotion software kit includes a series of functions for using LabWindows/CVI with National Instruments motion controllers.

# Optional Equipment

National Instruments offers a variety of products to use with 7324/7314 controllers, including cables, connector blocks, Universal Motion Interfaces (UMIs), driver amplifier units, and other accessories, as follows:

- Cables and cable assemblies
- Connector blocks, shielded and unshielded 68-pin screw terminals
- UMI connectivity blocks with integrated motion signal conditioning and motion inhibit functionality
- Stepper motor compatible driver amplifier units with integrated power supply and wiring connectivity

For more specific information about these products, refer to your National Instruments catalogue, the motion control product brochure, or call the office nearest you.

# Motion Signal and Motion I/O Connections

You access the motion I/O signals through an external 68-position connector on the 7324/7314. The 7324/7314 controllers use a high-density 68-pin female VHDCI connector.

The 24-bit digital I/O port on the 7324/7314 controllers is accessed through an external high-density 68-pin female VHDCI connector.

You can use any compatible mating connector, including insulation displacement ribbon cable connectors and discrete wire mating connectors.

**Note** Refer to Appendix C, *Differences on Older PXI Controllers*, for information of signal connections on versions of the PXI controllers older than revision D.

# 2

# Configuration and Installation

This chapter describes how to configure and install your 7324/7314 controller.

## Software Installation

Install your ValueMotion driver software, along with the VI libraries (if appropriate) before you install the 7324/7314 controller. Refer to the appropriate release notes and your software documentation for specific instructions on the software installation sequence.

## Controller Configuration

There are two types of configuration to be performed on the controllers: bus-related and motion I/O-related configuration.

Both the PCI and PXI controllers are fully compatible with the *PCI Local Bus Specification, Revision 2.1*. This compatibility allows the computer to automatically perform all bus-related configuration and requires no user interaction. There are no jumpers to configure for bus-related configuration.

The motion I/O-related configuration includes such settings as limit switch polarity, I/O port direction, motion mechanical system properties, and others. Most of these settings are software configurable, while some require hardware jumpers to be configured properly. Refer to Chapter 4, *Signal Connections*, for motion I/O-related hardware jumper settings.

# Hardware Installation

You can install the 7324/7314 controller in any open +5 V PCI or PXI expansion slot in your computer. The following are general installation instructions, but consult your computer user manual or technical reference manual for specific instructions and warnings.

- PCI controllers
  1. Turn off and unplug your computer.
  2. Remove the top cover or access port to the I/O channel.
  3. Remove the expansion slot cover on the back panel of the computer.
  4. Insert the 7324/7314 controller into a 5 V PCI slot as appropriate. Gently rock the controller to ease it into place. It may be a tight fit, but *do not force* the controller into place.
  5. If required, screw the mounting bracket of the 7324/7314 controller to the back panel rail of the computer.
  6. Replace the cover.
  7. Plug in and turn on your computer.

  Your PCI controller is installed.

- PXI controllers
  1. Turn off and unplug your chassis.
  2. Choose an unused 5 V peripheral slot.
  3. Remove the filler panel for the peripheral slot you have chosen.
  4. Touch a metal part on your chassis to discharge any static electricity that might be on your clothes or body.
  5. Insert the PXI controller into the slot. Use the injector/ejector handle to fully inject the device into place.
  6. Screw the front panel of the PXI controller to the front panel mounting rails of the chassis.
  7. Visually verify the installation.
  8. Plug in and turn on the chassis.

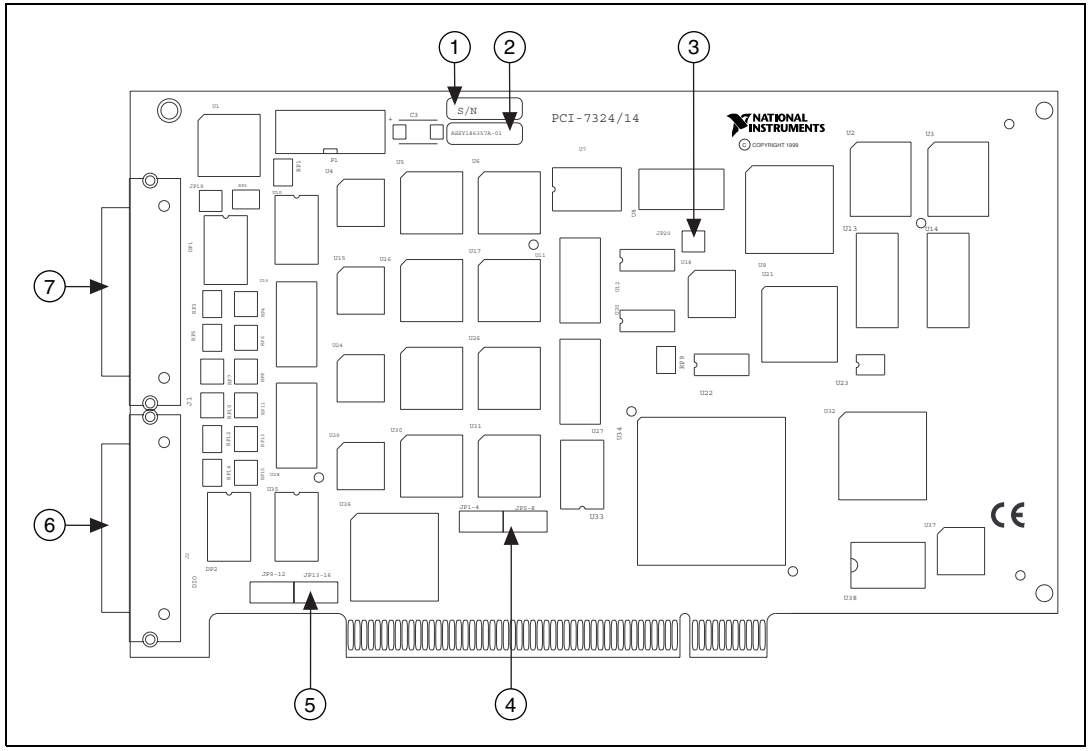
  Your PXI controller is installed.

# 3

# Hardware Overview

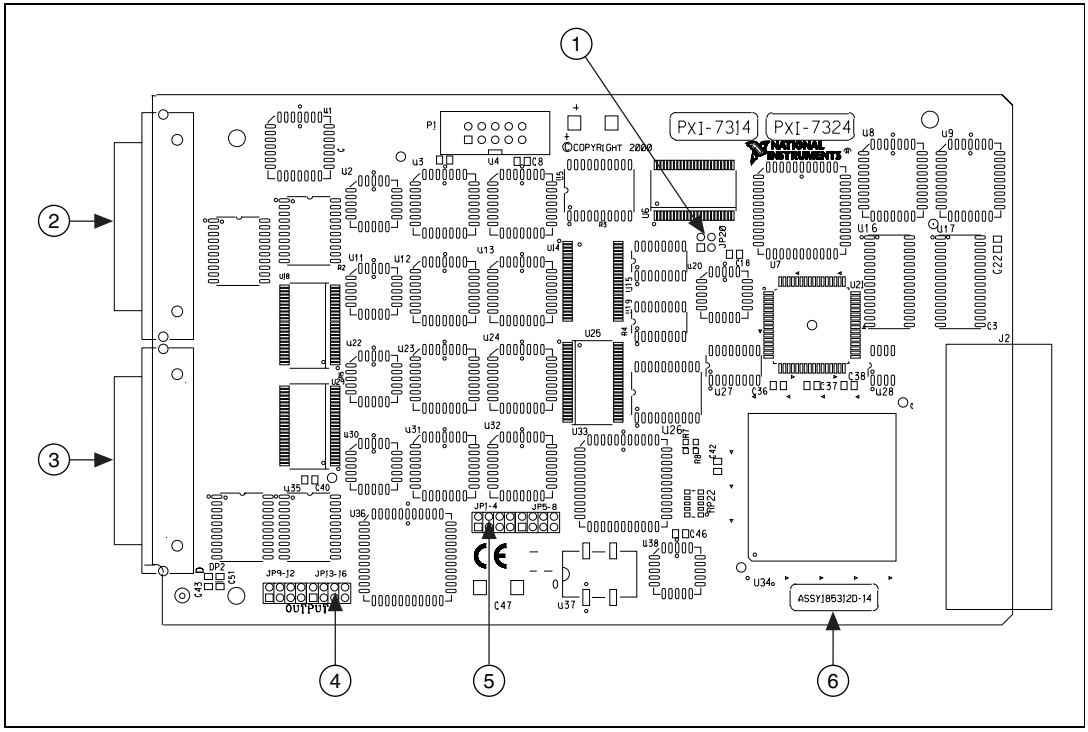
This chapter presents an overview of the hardware functionality of your 7324/7314 controller.

Figures 3-1 and 3-2 show the PCI and PXI parts locator diagrams, respectively.




| | | |
|---|---|---|
| 1 Serial Number | 4 Input Jumpers | 6 68-Pin Digital I/O Connector |
| 2 Assembly Number | 5 Output Jumpers | 7 68-Pin Motion I/O Connector |
| 3 Port C Direction Jumper | | |

**Figure 3-1.** PCI Controller Parts Locator Diagram




| | | | | | |
|---|---|---|---|---|---|
| 1 | Port C Direction Jumper | 3 | 68-Pin Digital I/O Connector | 5 | Input Jumpers |
| 2 | 68-Pin Motion I/O Connector | 4 | Output Jumpers | 6 | Assembly Number |

**Figure 3-2.** PXI Controller Parts Locator Diagram

# Functional Modes

## Trapezoidal Profile Position Control

The 7324/7314 controllers implement trapezoidal profile control. They provide point-to-point motion based on the difference between the current position and the desired target position using preprogrammed acceleration and velocity values. The trapezoidal motion profile is calculated based on the move duration, maximum velocity, and desired acceleration. Motion occurs first with a programmable acceleration, then for a period at a constant velocity (if possible) and finally with a preprogrammed deceleration to the desired target position. You can interrupt motion by halt-stopping via a limit or home switch input or you can execute a stop or kill function. The controllers also have a programmable acceleration factor that boosts the acceleration at low speeds to match the inherent torque versus speed characteristics of stepper motor systems.

The controllers require parameter loading in conjunction with motion trajectory function-level programming. The open-loop stepper controller parameters are expressed primarily in terms of steps, step count, and steps/second. Functions accessing closed-loop functions, which are only available on 7324 controllers, also use steps/revolution, encoder lines/revolution, and quadrature encoder counts. In LabVIEW, you configure parameters in units including revolutions per minute (RPM) and revolutions per second per second (RPSPS).

## Velocity Control

With the velocity control mode, you can continue motion at a preprogrammed velocity until a limit or home switch is encountered or until a stop or kill function is executed.

## Velocity Profiling

With the velocity profiling mode, you can preprogram initial acceleration to a desired velocity that is maintained until a new velocity value is loaded. New velocity values may be loaded at any time. The system executes the most recent function and attains the new programmed velocity. Motion is continuous until a limit or home switch is encountered or until a stop or kill function is executed. This mode is useful for continuous contouring applications.

**Note** Stepper controllers do not use the acceleration value when changing to a new velocity, which can result in an abrupt motion for large velocity changes.

## Event-Based Motion Profiling

7324/7314 controllers offer the advanced feature of event-based motion profiling. Event-based motion profiling involves preloading motion control functions into onboard memory trigger buffers. You can then execute single or multiple move sequences using digital I/O trigger events. Triggers can be external I/O events or manual trigger functions sent by the host computer under function control. You can use the event-based motion profiling mode for semi-autonomous operation or for precise coordination with external events.

# Trajectory Parameters

The trajectory parameters the controllers use are expressed in terms of steps for open-loop functions or quadrature counts for closed-loop functions.

The controllers obtain closed-loop position and velocity control by using an incremental quadrature encoder for feedback. All position data is referred to in quadrature counts. You can determine quadrature counts with the following equation:

$$Encoder\ Lines\ Per\ Index\ Period \times 4$$

The encoder resolution is the number of encoder lines between consecutive encoder indexes (marker or Z-bit). If the encoder does not have an index output, the resolution is referred to as lines per revolution for rotary encoders and as lines per inch (or millimeters) for linear encoders.

Refer to the *ValueMotion Software Reference Manual* for specific information on loading trajectory parameters to your 7324/7314 controller.

## Position Value Loading

For closed-loop stepper operation, position is specified in quadrature counts as a signed number. The number of quadrature counts per revolution depends upon the incremental encoder used for feedback.

For open-loop stepper operation, position is specified in step counts as a signed number. The number of step counts per revolution depends upon the type of stepper driver and motor being used. For example, a stepper motor with 1.8°/step (200 steps/revolution) used in conjunction with a *x*10 microstep driver would have an effective resolution of 2,000 steps per revolution. 7324/7314 controllers support all full, half, and microstep applications.

## Velocity Value Loading

Velocity is expressed as the change in position divided by time. For closed-loop stepper operation, position is specified in quadrature counts. For open-loop stepper operation, position is specified in step counts. You can use the following formulas to convert revolutions per minute (RPM) to quadrature or step counts per second:

- Quadrature counts per second:

$$Velocity = (Velocity\ in\ RPM) \times (Encoder\ Lines) \times (4) \times (1/60)$$

- Step counts per second:

$$Velocity = (Velocity\ in\ RPM) \times (Driver\ Steps/Motor\ Step) \times (Motor\ Steps/Rev) \times (1/60)$$

To determine the driver steps/motor step, configure the stepper driver. The driver steps/motor steps ratio is 1 for full step, 1/2 for half step, and 1/*n* for microstep where *n* is the microstep value.

## Acceleration Value Loading

Acceleration is expressed as the change in velocity divided by time, which is equivalent to change in position divided by time divided by time. For closed-loop stepper operation, position is specified in quadrature counts. For open-loop stepper operation, position is specified in step counts. Use the following formulas to convert revolutions per second per second (RPSPS) to quadrature or step counts per second per second:

- Quadrature counts per second per second:

$$Acceleration = (Acceleration\ in\ RPSPS) \times (Encoder\ Lines) \times (4)$$

- Step counts per second per second:

$$Acceleration = (Acceleration\ in\ RPSPS) \times (Driver\ Steps/Motor\ Step) \times (Motor\ steps/Rev)$$

To determine the driver steps/motor step, configure the stepper driver. The driver steps/motor steps ratio is 1 for full step, 1/2 for half step, and 1/*n* for microstep where *n* is the microstep value.

# 4

# Signal Connections

This chapter describes how to make input and output signal connections to the 7324/7314 controllers.

**Note** Throughout this document, a line above a signal name indicates that the signal is active-low.

**Warning** Do not rely on any general purpose digital line states during power-up or power-down of the system.

# Motion I/O Connector

Figure 4-1 shows the pin assignments for the 68-pin motion I/O connector on the 7324/7314 controllers.

| | | | |
|---|---|---|---|
| Axis 1 Dir (CCW) | 1 | 35 | Axis 1 Step (CW) |
| Digital Ground | 2 | 36 | Axis 1 Encoder Phase A |
| Digital Ground | 3 | 37 | Axis 1 Encoder Phase B |
| Axis 1 Home Switch | 4 | 38 | Axis 1 Encoder $\overline{\text{Index}}$ |
| Trigger 1 | 5 | 39 | Axis 1 Forward Limit Switch |
| Axis 1 $\overline{\text{Inhibit}}$ | 6 | 40 | Axis 1 Reverse Limit Switch |
| Axis 2 Dir (CCW) | 7 | 41 | Axis 2 Step (CW) |
| Digital Ground | 8 | 42 | Axis 2 Encoder Phase A |
| Digital Ground | 9 | 43 | Axis 2 Encoder Phase B |
| Axis 2 Home Switch | 10 | 44 | Axis 2 Encoder $\overline{\text{Index}}$ |
| Trigger 2 | 11 | 45 | Axis 2 Forward Limit Switch |
| Axis 2 $\overline{\text{Inhibit}}$ | 12 | 46 | Axis 2 Reverse Limit Switch |
| Axis 3 Dir (CCW) | 13 | 47 | Axis 3 Step (CW) |
| Digital Ground | 14 | 48 | Axis 3 Encoder Phase A |
| Digital Ground | 15 | 49 | Axis 3 Encoder Phase B |
| Axis 3 Home Switch | 16 | 50 | Axis 3 Encoder $\overline{\text{Index}}$ |
| Trigger 3 | 17 | 51 | Axis 3 Forward Limit Switch |
| Axis 3 $\overline{\text{Inhibit}}$ | 18 | 52 | Axis 3 Reverse Limit Switch |
| Axis 4 Dir (CCW) | 19 | 53 | Axis 4 Step (CW) |
| Digital Ground | 20 | 54 | Axis 4 Encoder Phase A |
| Digital Ground | 21 | 55 | Axis 4 Encoder Phase B |
| Axis 4 Home Switch | 22 | 56 | Axis 4 Encoder $\overline{\text{Index}}$ |
| Trigger 4 | 23 | 57 | Axis 4 Forward Limit Switch |
| Axis 4 $\overline{\text{Inhibit}}$ | 24 | 58 | Axis 4 Reverse Limit Switch |
| Digital Ground | 25 | 59 | Host +5 V |
| Breakpoint 1 | 26 | 60 | Breakpoint 2 |
| Breakpoint 3 | 27 | 61 | Breakpoint 4 |
| Reserved | 28 | 62 | Reserved |
| Reserved | 29 | 63 | Reserved |
| Reserved | 30 | 64 | Reserved |
| Reserved | 31 | 65 | Reserved |
| Analog Input 1[1] | 32 | 66 | Analog Input 2[1] |
| Analog Input 3[1] | 33 | 67 | Analog Input 4[1] |
| Analog Reference (Output)[1] | 34 | 68 | Analog Input Ground[1] |

[1]Not connected on 7314 controllers

**Figure 4-1.** 68-Pin Stepper Pin Assignment

Table 4-1 describes the signals on the I/O connectors.

**Table 4-1.** Signal Descriptions for I/O Connector Pins

| Signal Name | Reference | Direction | Description |
|---|---|---|---|
| Axis <1..4> Dir (CCW) | Digital Ground | Output | Motor direction or counter-clockwise control |
| Axis <1..4> Step (CW) | Digital Ground | Output | Motor step or clockwise control |
| Axis <1..4> Encoder Phase A | Digital Ground | Input | Closed-loop only—phase A encoder input |
| Axis <1..4> Encoder Phase B | Digital Ground | Input | Closed-loop only—phase B encoder input |
| Axis <1..4> Encoder $\overline{\text{Index}}$ | Digital Ground | Input | Closed-loop only—index encoder input |
| Axis <1..4> Home Switch | Digital Ground | Input | Home switch |
| Axis <1..4> Forward Limit Switch | Digital Ground | Input | Forward/clockwise limit switch |
| Axis <1..4> Reverse Limit Switch | Digital Ground | Input | Reverse/counter-clockwise limit switch |
| Axis <1..4> $\overline{\text{Inhibit}}$ | Digital Ground | Output | Drive inhibit |
| Trigger <1..4> | Digital Ground | Input | Input bit <1..4> |
| Breakpoint <1..4> | Digital Ground | Output | Output bit <1..4> |
| Host +5 V | Digital Ground | Output | +5 V— host bus interlock |
| Analog Input Ground | — | — | Reference for analog inputs |
| Analog Input <1..4> | Analog Input Ground | Input | 8-bit analog input |
| Analog Reference (output) | Analog Input Ground | Output | +5 V—analog reference level |
| Digital Ground | — | — | Reference for digital I/O |

## External Connector Wiring Recommendations

The external connectors are divided into five separate sections for the purpose of wiring descriptions. Four of the sections are identical in pinout, format, and connector configuration. Each of these four identical sections corresponds to an individual axis controller circuit. The fifth section is the bus power interlock section.

Each per-axis motion I/O connector subsection consists of four functional areas:

- Motor drive outputs
- Encoder feedback inputs
- Limit and home switch inputs
- Related motion I/O port bits

**Caution** You must wire these four function groups separately from each other to prevent noise or signal crosstalk from affecting adjacent signal groups. Failure to take these simple precautions may cause faulty operation.

It is important to note that the 7324/7314 I/O connector provides numerous ground connections. Proper use of these ground connections will help to prevent unwanted signal disturbance and noise. Use these ground connections as ground current return paths or as shield connections for proper signal grounding.

## Bus Power Signal

The bus power +5 V signal is available for bus monitoring and interlock purposes. It is not intended to power external circuitry or components. Current draw should not exceed 100 mA.

## Trigger, Breakpoint, and Inhibit Signals

The following sections describe hardware jumper selection and the specifications for trigger, breakpoint, and inhibit signal interconnection. For correct operation, you must execute motion system setup, including I/O port software initialization, using the ValueMotion functions before you can use the trigger, breakpoint, and inhibit signals.

The controllers create the trigger, breakpoint, and inhibit signals from a single 8-bit bidirectional port. I/O port bits <1..4> are used for the trigger and breakpoint signals. When configured as an input, the I/O port bit can be used as a trigger or general-purpose input. When configured as an output, the I/O port bit can be used as either a breakpoint or general-purpose output. I/O port bits <5..8> are used for the inhibit signals. When configured as an output, the I/O port bit is the axis inhibit output. When configured as an input, the I/O port bit is a general-purpose input.

### Input Signals

Input signals to the I/O port may be active-high or active-low. Proper operation depends upon correct setup and programming of I/O polarity and direction. Improper setup and programming may cause faulty operation.

### Output Signals

I/O port signals configured as outputs are single-ended TTL with internally pulled-up open-collector buffers. Pull-up resistors are 3.3 kΩ to +5 V. These buffers can sink 64 mA.

**Note** The PXI controllers prior to revision D do not include pull-up resistors on the breakpoint outputs. You must connect external pull-up resistors for proper operation of the breakpoint outputs when interfacing to TTL inputs that do not include built-in pull-up resistors.

## Wiring Concerns

**Caution** Keep I/O port signals and I/O port grounds wired separately from the motor drive signals. Wiring these signals near each other can cause faulty operation. Be sure to use adequate ground signal connections in conjunction with I/O port bit signal connections.

## Jumper Configuration

Two hardware jumper locations are available for each I/O port bit on the 7324/7314 controller. One of these locations is for input signal configuration and the other is for output signal configuration. The jumpers are used in conjunction with I/O port configuration and polarity programming to properly set up the I/O port function. The jumpers must be properly installed and must correspond to the direction programmed to ensure correct operation of the I/O port bits.

Table 4-2 shows the I/O port bit assignments and the corresponding hardware jumpers.

**Table 4-2.** Jumper Pin I/O Port Bit Correspondence

| I/O Port Bit Number | Input Jumper Number | Output Jumper Number |
|---|---|---|
| 1 | JP1 | JP9 |
| 2 | JP2 | JP10 |
| 3 | JP3 | JP11 |
| 4 | JP4 | JP12 |
| 5 | JP5 | JP13 |
| 6 | JP6 | JP14 |
| 7 | JP7 | JP15 |
| 8 | JP8 | JP16 |

**Caution** Never install both input and output jumpers for the same I/O port bit locations; for example, 1 and 9, 2 and 10, 3 and 11, and so on.

The 7324/7314 controllers have eight removable jumpers, located on input pins JP1 through JP4 and output pins JP13 through JP16 by default. Refer to Figures 3-1 and 3-2 in Chapter 3, *Hardware Overview*, for input/output jumper locations.

## I/O Port Hardware Circuit

Figures 4-2 and 4-3 show simplified schematic diagrams of the hardware circuitry used by the I/O ports for input signal buffering and output signal drive, as well as the jumper locations.

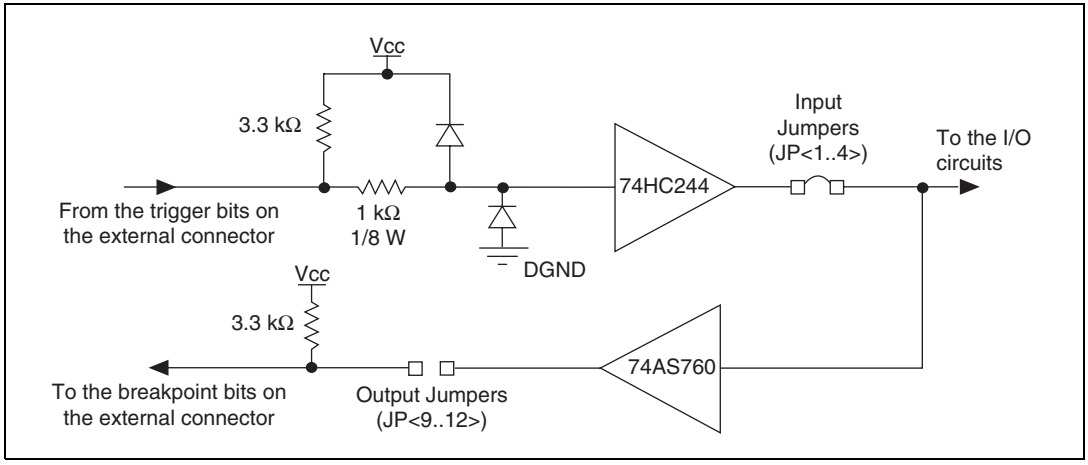



**Figure 4-2.** Trigger and Breakpoint Hardware Circuitry

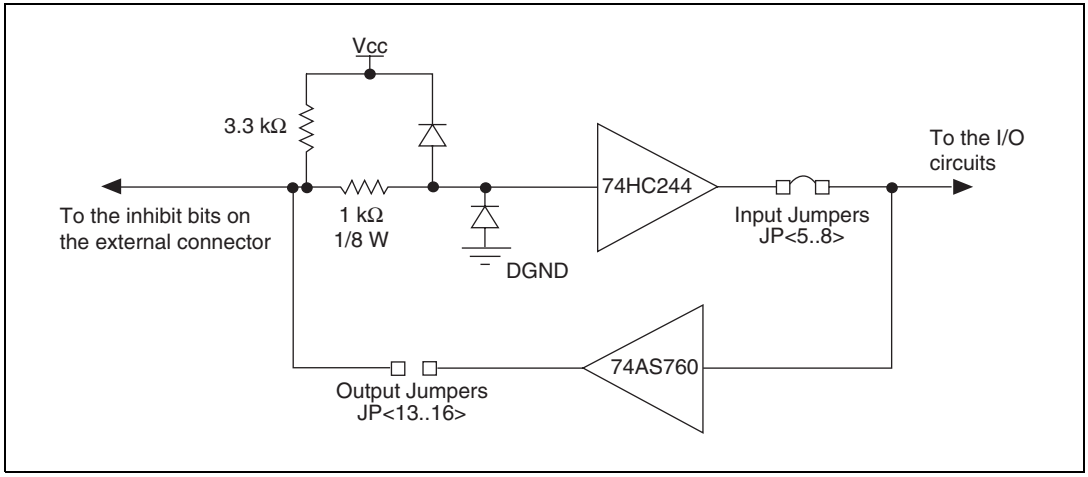



**Figure 4-3.** Inhibit Hardware Circuitry

The 7324/7314 controller protects input signals from over-voltage and misconnection of the I/O port bits. However, you must take care when making these and any other hardware wiring connections. 12 V input signals can be interfaced directly, but higher voltages should be avoided. With the 3.3 kΩ pull-up resistor, you can directly interface to open-collector signals.

**Caution** Excessive input voltages may cause component failure.

## Limit and Home Switches

Limit and home switch inputs can be software configured as active-high or active-low enabled single-ended signals. Limit and home switch inputs may be enabled and disabled through software. Unused limit inputs may be directly used as nondedicated, general-purpose digital input channels.

An active input signal on an enabled limit or home switch input causes motion to immediately decelerate or halt stop on the corresponding axis. Limit and home switch input signals perform special motion control functions during the Find Home function.

**Note** While limit switch transitions are edge-detected and stop motion, active inputs should remain active to prevent motion from proceeding further into the limit or in the limit direction. Pulsed signals cause motion to stop, but they do not prevent further motion profiles that are restarted beyond an active limit position.

Limit switch inputs are a per-axis, system-level enhancement on the 7324/7314 controllers and are not required for basic motion control. These inputs are part of a system solution for complete motion control. All motion control functions can be operated without limit switches except the Find Home function, which requires enabled limit inputs for operations.

### Wiring Concerns

**Caution** Keep limit and home switch signals and their ground connections wired separately from the motor driver/amplifier signal connections. Wiring these signals near each other can cause faulty operation.

## Limit and Home Switch Input Circuit

Figure 4-4 shows a simplified schematic diagram of the circuit configuration used by the limit and home switch inputs for input signal buffering and detection.

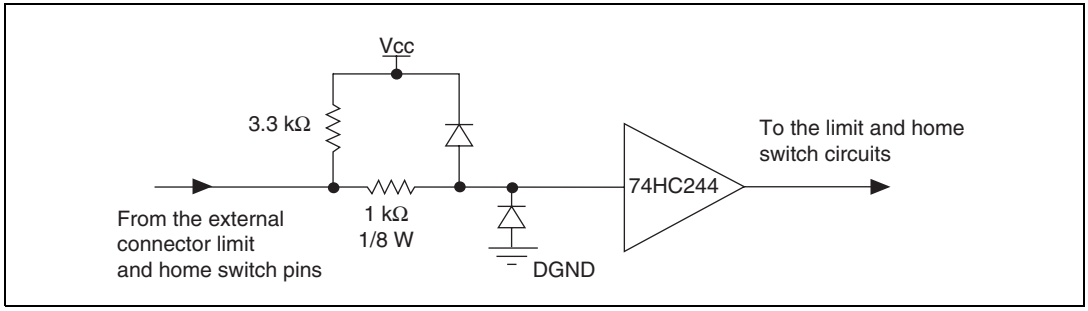



**Figure 4-4.** Limit Switch and Home Switch Input Hardware Circuitry

The 7324/7314 controller provides protection for over-voltage inputs on the limit and home switch input signal. However, take care when making these and any other hardware wiring connections. 12 V input signals can be interfaced directly, but higher voltages must be avoided. The 3.3 kΩ pull-up resistor allows you to interface to open-collector signals.

**Caution** Excessive input voltages can cause erroneous operation and/or component failure.

## Encoder Connections (7324 Controllers Only)

Encoder signal inputs are single-ended TTL signals. Take care to observe the phasing of the Phase A and Phase B encoder quadrature signals to ensure that the direction of motor motion and encoder feedback signals are coincident and correctly related. For more information, see Figure 4-5.

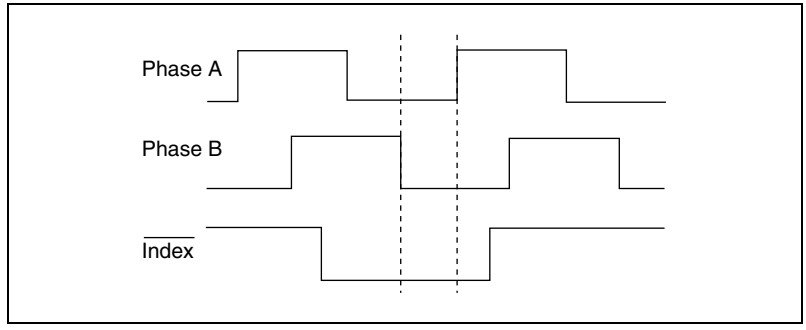



**Figure 4-5.** Quadrature Encoder Phasing Diagram

## Wiring Concerns

The encoder inputs are connected to quadrature decoder/counter circuits. You must minimize noise at this interface. Excessive noise on these input signals may result in loss of counts or extra counts and erroneous closed-loop motion operation. Verify the encoder connections before powering up the system.

**Caution** Wire encoder signals and their ground connections separately from the motor driver signal connections. Wiring these signals near each other causes mispositioning and faulty operation.

## Encoder Signals

7324 controllers expect quadrature encoder input feedback signals 90° out of phase from each other. Any deviation from this signal type, or excessive noise on the encoder signals, causes faulty operation and lost quadrature counts.

**Note** Determine quadrature counts by multiplying the encoder resolution in encoder lines by 4. The encoder resolution is the number of encoder lines between consecutive encoder indexes (marker or Z-bit). If the encoder does not have an index output, the resolution would be referred to as lines per revolution, or lines per unit of measure (in., cm, mm, and so on).

## Encoder Index Signal

You can use the 7324 controllers with an active-low index (marker or Z-bit) input. This signal must be single-ended, TTL compatible, and properly phased in both polarity and sequence with respect to the Phase A and Phase B input signals. See Figure 4-5 for more information about the quadrature encoder phasing. The index state is defined when all three signals, Phase A, Phase B, and $\overline{\text{Index}}$, are low. To avoid redundancy, the $\overline{\text{Index}}$ signal must be less than 360° of a full quadrature period. Improper $\overline{\text{Index}}$ signal connection and configuration may cause faulty operation during the Find Index function. If this function is not working properly, check the encoder index signal connection, polarity, and sequence.

## Encoder Signal Input Circuit

Figure 4-6 shows a simplified schematic diagram of the hardware circuit used by the encoder inputs for input signal buffering.

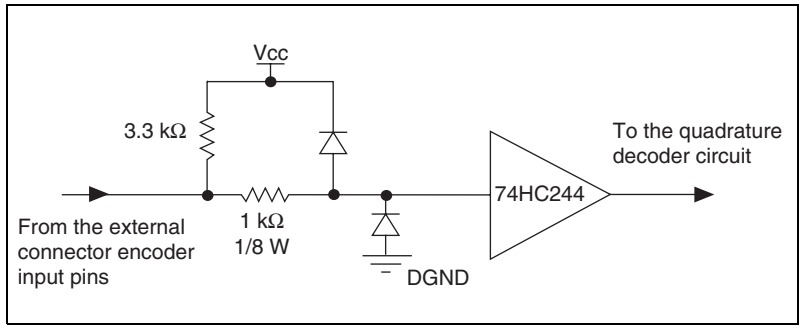



**Figure 4-6.** Encoder Feedback Input Hardware Circuitry

The 7324 controller provides protection for over-voltage inputs and misconnection of the Encoder Input signals. However, take care when making these and any other hardware wiring connections. The 3.3 kΩ pull-up resistor allows you to connect to open-collector signals.

**Caution** Excessive input voltages can cause component failure.

# Digital I/O Connector

You can program the digital I/O port for general-purpose digital I/O functionality. The 24-bit digital I/O port is configured in hardware as three 8-bit digital I/O ports. The three byte wide 8-bit ports are referred to as ports A, B, and C. The auxiliary 24-bit digital I/O on the controllers is accessed from a 68-pin connector as shown in Figure 4-7.

**Note** Refer to Appendix C, *Differences on Older PXI Controllers*, for connectivity information for versions of PXI controllers previous to revision D.

| | | | |
|---|---|---|---|
| +5 V | 1 | 35 | Digital Ground |
| Reserved | 2 | 36 | Digital Ground |
| Reserved | 3 | 37 | Digital Ground |
| Reserved | 4 | 38 | Reserved |
| Reserved | 5 | 39 | Digital Ground |
| Reserved | 6 | 40 | Reserved |
| Reserved | 7 | 41 | Digital Ground |
| Reserved | 8 | 42 | Digital Ground |
| Reserved | 9 | 43 | Digital Ground |
| Digital I/O 1 | 10 | 44 | Digital I/O 2 |
| Digital Ground | 11 | 45 | Digital I/O 3 |
| Digital I/O 4 | 12 | 46 | Digital Ground |
| Digital I/O 5 | 13 | 47 | Digital I/O 6 |
| Digital Ground | 14 | 48 | Digital I/O 7 |
| Digital I/O 8 | 15 | 49 | Digital Ground |
| Digital I/O 9 | 16 | 50 | Digital Ground |
| Digital I/O 10 | 17 | 51 | Digital I/O 11 |
| Digital Ground | 18 | 52 | Digital I/O 12 |
| Digital Ground | 19 | 53 | Digital I/O 13 |
| Digital Ground | 20 | 54 | Digital I/O 14 |
| Digital I/O 15 | 21 | 55 | Digital Ground |
| Digital I/O 16 | 22 | 56 | Digital Ground |
| Digital I/O 17 | 23 | 57 | Digital I/O 18 |
| Digital Ground | 24 | 58 | Digital I/O 19 |
| Digital I/O 20 | 25 | 59 | Digital Ground |
| Digital I/O 21 | 26 | 60 | Digital I/O 22 |
| Digital Ground | 27 | 61 | Digital I/O 23 |
| Digital I/O 24 | 28 | 62 | Digital Ground |
| Reserved | 29 | 63 | Reserved |
| Digital Ground | 30 | 64 | Reserved |
| Reserved | 31 | 65 | Digital Ground |
| Reserved | 32 | 66 | Reserved |
| Digital Ground | 33 | 67 | Reserved |
| Reserved | 34 | 68 | Digital Ground |

**Figure 4-7.** 68-Pin Digital I/O Connector

Port A consists of digital I/O bits 1 through 8 available on the digital I/O connector. Always configure these bits as inputs. The data read from the Port A bits will always reflect the actual input bit levels. If Port A is configured for output bits, writing output data to Port A does nothing. For more information, see Figure 4-8.

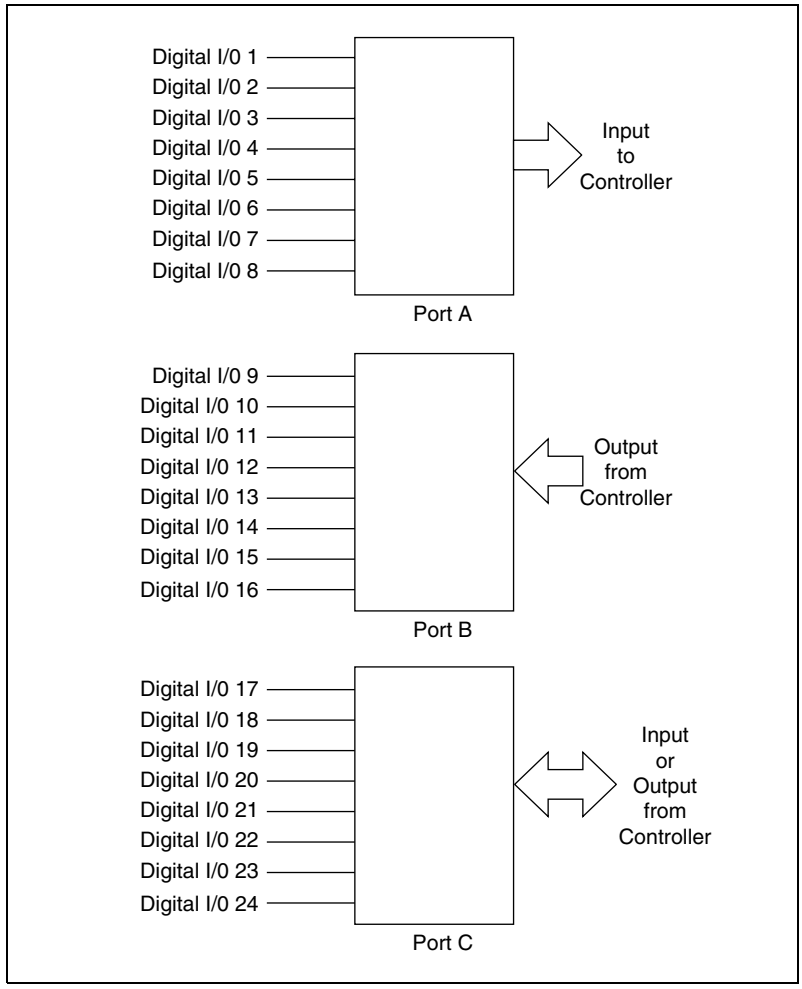



**Figure 4-8.** Digital I/O Port Configuration

Port B consists of digital I/O bits 9 through 16 available on the digital I/O connector. Always configure these bits as outputs. The data written to the Port B bits reflects the actual output bit levels. Port B cannot be configured for input bits. Reading input data from Port B returns the programmed output values. See Figure 4-8 for more information.

Readback of the Port B bit data can be very useful in programming these bits. By reading back the present output bit settings and then using logical binary functions, you can directly mask and set output data values for this port. If the output data is independent of the present value of output Port B,

it is also simple to write the new desired bit levels to the port directly overriding the previous values.

Port C consists of digital I/O bits 17 through 24 available on the digital I/O connector. You can configure these bits as a byte wide input or output port. You can configure Port C direction as all output bits or all input bits by using two required configuration settings.

Complete the following steps to set the Port C direction:

1. Set the jumper (item 3 in Figure 3-1, *PCI Controller Parts Locator Diagram*, for PCI, item 2 in Figure 3-2, *PXI Controller Parts Locator Diagram*, for PXI) to input or output to select the hardware direction configuration for Port C. Refer to Figure 4-9 for more information on jumper configuration.
2. Use the Set Aux. I/O Port Output function to set up the desired Port C direction of the Port C data byte. Refer to your *ValueMotion Software Reference Manual* for more information on software functions.

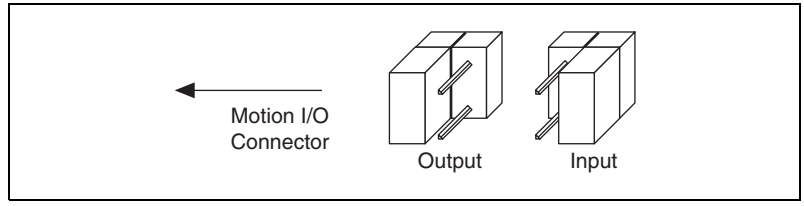



**Figure 4-9.** PCI- and PXI-Step Port C Direction Setting

Data can be written to the Port C bits when they are configured as output bits, and the outputs will reflect the desired output bit levels set. Reading data from Port C returns the actual data input or user-programmed output values for the bits depending on Port C direction selected.

Readback of the Port C bit data can be very useful in programming these bits. By reading back the present output bit settings and then using logical binary functions, you can directly mask and set output data values for this port. If the output data is independent of the present value of the output Port C, it is also simple to write the new desired bit levels to the port directly.

# ADC Inputs

The 7324 controllers contain a multi-channel analog-to-digital converter (ADC) for basic analog input operations. Both the PCI and PXI controllers provide four analog input channels on the external 68-pin motion connector.

**Note** Older PXI controllers (revision C and earlier) include an additional four channels. Refer to *ADC Inputs* in Appendix C, *Differences on Older PXI Controllers*, for more information.

You can configure the multi-channel ADC on the controller for simple A/D conversion or motion integrated functionality. The ADC is a 0 and 5 V range 8-bit converter. You can use the A/D input channels independently as analog inputs.

You can read back the analog voltage input digital representation on any of the controller's eight ADC channels by using the Read A/D function. The values read back will be in the following range:

$$0 \leq \textit{Analog Input Number Readback Value} \leq 255$$

You can read any channel by indicating the desired channel number when using the A/D readback function.

# A

# Specifications

This appendix lists the specifications of your 7324/7314 controller. These specifications are typical at 25 °C unless otherwise noted.

**Note** For older PXI controllers (revision C and earlier), refer to *Physical Specifications* in Appendix C, Differences On Older PXI Controllers.

## Stepper Performance

Max step frequency ..... 750,000 steps/s

Absolute position range .....± $2^{31}$ steps

Max relative move size .....± $2^{21}$ steps

Max encoder frequency.....1 MHz

## Motion Digital I/O

### Input Circuits (Including Encoder Feedback, Limit Switches, and Trigger Inputs)

Input voltage range..... 0 to 12 V

Input low voltage ..... 0.8 V

Input high voltage ..... 2 V

### Output Circuits (Including Step, Direction, and Breakpoint Outputs)

Output voltage range ..... 0 to 5 V

Output low voltage..... < 0.6 V at 64 mA

Output high voltage..... 3.3 k pull-up to +5 V (open collector)

**Note** Pull-ups are not provided on breakpoint outputs on versions of PXI controllers prior to revision D.

## 24-Bit Digital I/O

Input voltage range .....0 to 5 V

Input low voltage .....0.8 V

Input high voltage .....2 V

Output voltage range .....0 to 5 V

Output low voltage .....< 0.5 V at 24 mA

Output high voltage .....> 2.4 V at 3 mA

## Analog Input (7324 Only)

Input voltage range .....0 to Vcc (Vcc = +5 V ± 3%)

Resolution .....8 bits

## Power Requirements (Max)

+5 (± 3%).....1.2 A

+12 V (±3%).....0 A

–12 V (±3%) .....0 A

Power consumption .....6 W

## Physical

### Dimensions (Not Including Connectors)

PCI controllers.....17.5 by 9.9 cm (6.9 by 3.9 in.)

PXI controllers.....16 by 10 cm (6.3 by 3.9 in.)

### Motion I/O Connector

Both controllers .....68-pin female VHDCI type

## Digital I/O Connector

Both controllers..... 68-pin female VHDCI type

# Environment

Operating temperature..... 0 to 55 °C

Storage temperature .....–20 to 70 °C

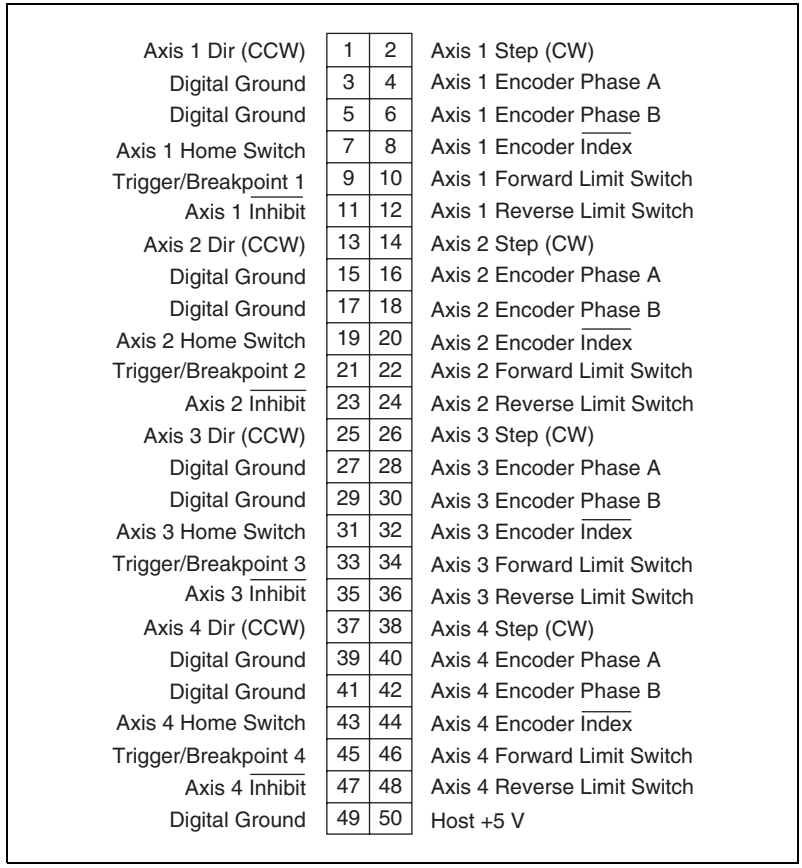
Relative humidity range .....10 to 90% (noncondensing)

# B

# Cable Connector Descriptions

This appendix describes the connectors on the optional cables for your 7324/7314 controller. Figure B-1 shows the pin assignments for the 50-pin motion connector. This connector is available when you use the SH68-C68-S shielded cable assembly and the 68M-50F Step Bulkhead Cable Adapter with the 7324/7314 controllers. The 50-pin motion connector would be useful when you are connecting to a legacy ValueMotion, nuDrive, or UMI-4A motor drive.

**Note** On PXI controllers that precede revision D, the 50-pin motion connector is available when you use the SH68-68-S shielded cable assembly and the 68M-50F Step Bulkhead Cable Adapter.



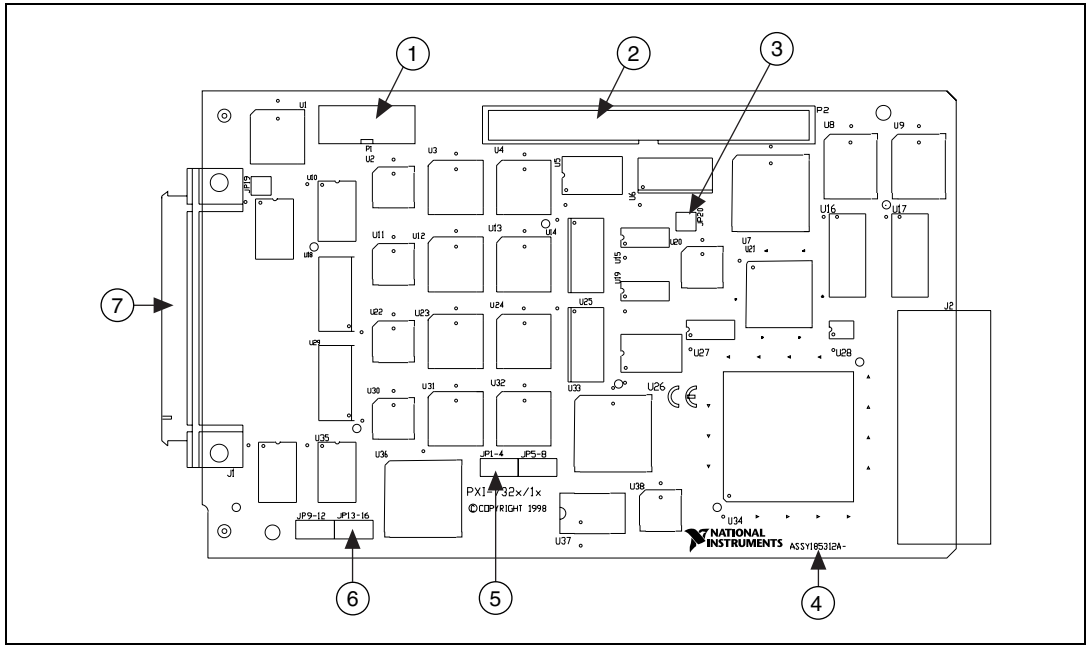
| | | | |
|---|---|---|---|
| Axis 1 Dir (CCW) | 1 | 2 | Axis 1 Step (CW) |
| Digital Ground | 3 | 4 | Axis 1 Encoder Phase A |
| Digital Ground | 5 | 6 | Axis 1 Encoder Phase B |
| Axis 1 Home Switch | 7 | 8 | Axis 1 Encoder $\overline{\text{Index}}$ |
| Trigger/Breakpoint 1 | 9 | 10 | Axis 1 Forward Limit Switch |
| Axis 1 $\overline{\text{Inhibit}}$ | 11 | 12 | Axis 1 Reverse Limit Switch |
| Axis 2 Dir (CCW) | 13 | 14 | Axis 2 Step (CW) |
| Digital Ground | 15 | 16 | Axis 2 Encoder Phase A |
| Digital Ground | 17 | 18 | Axis 2 Encoder Phase B |
| Axis 2 Home Switch | 19 | 20 | Axis 2 Encoder $\overline{\text{Index}}$ |
| Trigger/Breakpoint 2 | 21 | 22 | Axis 2 Forward Limit Switch |
| Axis 2 $\overline{\text{Inhibit}}$ | 23 | 24 | Axis 2 Reverse Limit Switch |
| Axis 3 Dir (CCW) | 25 | 26 | Axis 3 Step (CW) |
| Digital Ground | 27 | 28 | Axis 3 Encoder Phase A |
| Digital Ground | 29 | 30 | Axis 3 Encoder Phase B |
| Axis 3 Home Switch | 31 | 32 | Axis 3 Encoder $\overline{\text{Index}}$ |
| Trigger/Breakpoint 3 | 33 | 34 | Axis 3 Forward Limit Switch |
| Axis 3 $\overline{\text{Inhibit}}$ | 35 | 36 | Axis 3 Reverse Limit Switch |
| Axis 4 Dir (CCW) | 37 | 38 | Axis 4 Step (CW) |
| Digital Ground | 39 | 40 | Axis 4 Encoder Phase A |
| Digital Ground | 41 | 42 | Axis 4 Encoder Phase B |
| Axis 4 Home Switch | 43 | 44 | Axis 4 Encoder $\overline{\text{Index}}$ |
| Trigger/Breakpoint 4 | 45 | 46 | Axis 4 Forward Limit Switch |
| Axis 4 $\overline{\text{Inhibit}}$ | 47 | 48 | Axis 4 Reverse Limit Switch |
| Digital Ground | 49 | 50 | Host +5 V |

**Figure B-1.** 50-Pin Stepper Connector Pin Assignment

# C

# Differences on Older PXI Controllers

This appendix provides reference information for PXI 7324/7314 controllers labelled as revision C or earlier. *These specifications do not apply to new controllers.*




| | | | | | |
|---|---|---|---|---|---|
| 1 | A/D Converter Input 10-Pin Connector | 3 | Port C Direction Jumper | 6 | Output Jumpers |
| 2 | 50-Pin Digital I/O Connector | 4 | Assembly Number | 7 | 68-Pin Motion I/O Connector |
| | | 5 | Input Jumpers | | |

**Figure C-1.** PXI Controller Parts Locator Diagram for Revision C or Earlier

# Digital I/O Connector

The digital I/O on the PXI controllers is accessed from a 50-pin connector as shown in Figure C-2.

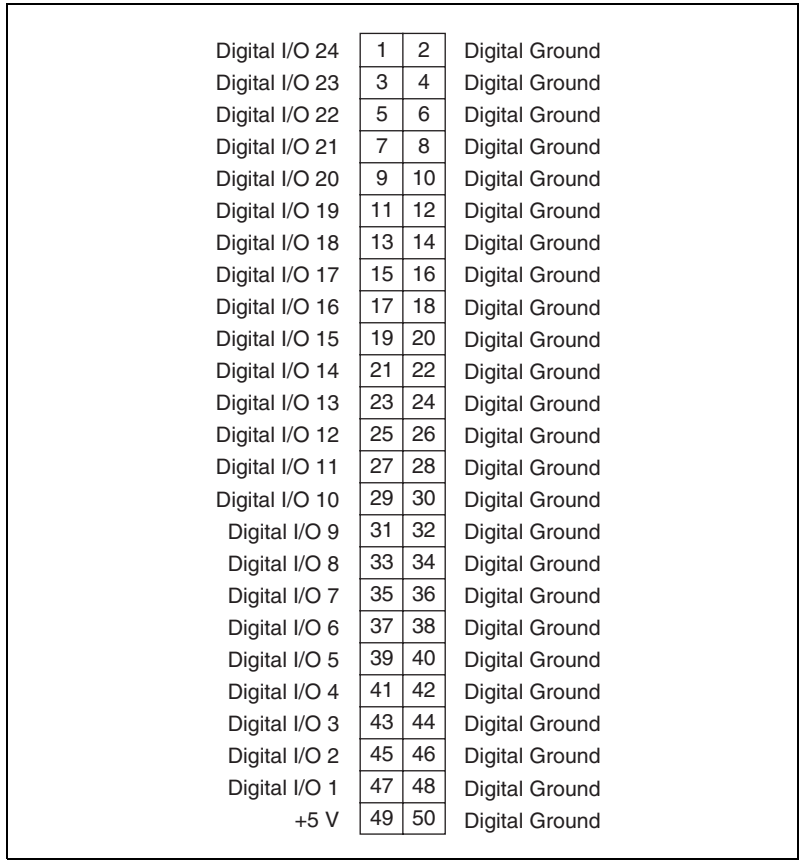

Digital I/O 24 1 2 Digital Ground
Digital I/O 23 3 4 Digital Ground
Digital I/O 22 5 6 Digital Ground
Digital I/O 21 7 8 Digital Ground
Digital I/O 20 9 10 Digital Ground
Digital I/O 19 11 12 Digital Ground
Digital I/O 18 13 14 Digital Ground
Digital I/O 17 15 16 Digital Ground
Digital I/O 16 17 18 Digital Ground
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**Figure C-2.** 50-Pin Digital I/O Connector for Revision C or Earlier

# ADC Inputs

Older PXI controllers (revision C and earlier) include an additional four channels, all eight of which are available on an internal 10-pin connector as shown in Figure C-3.

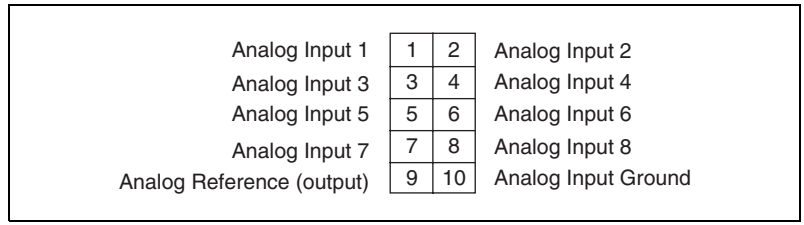


**Figure C-3.** External Pin Assignment for the ADC Connector (Revision C or Earlier)

# Physical Specifications

This section lists differing physical specifications on PXI version C or earlier.

## Motion I/O Connector

PXI controllers ..... 68-pin male SCSI-II type

## Digital I/O Connector

PXI controllers ..... 50-pin male box-header

# D

# Technical Support Resources

## Web Support

National Instruments Web support is your first stop for help in solving installation, configuration, and application problems and questions. Online problem-solving and diagnostic resources include frequently asked questions, knowledge bases, product-specific troubleshooting wizards, manuals, drivers, software updates, and more. Web support is available through the Technical Support section of `ni.com`

## NI Developer Zone

The NI Developer Zone at `ni.com/zone` is the essential resource for building measurement and automation systems. At the NI Developer Zone, you can easily access the latest example programs, system configurators, tutorials, technical news, as well as a community of developers ready to share their own techniques.

## Customer Education

National Instruments provides a number of alternatives to satisfy your training needs, from self-paced tutorials, videos, and interactive CDs to instructor-led hands-on courses at locations around the world. Visit the Customer Education section of `ni.com` for online course schedules, syllabi, training centers, and class registration.

## System Integration

If you have time constraints, limited in-house technical resources, or other dilemmas, you may prefer to employ consulting or system integration services. You can rely on the expertise available through our worldwide network of Alliance Program members. To find out more about our Alliance system integration solutions, visit the System Integration section of `ni.com`

# Worldwide Support

National Instruments has offices located around the world to help address your support needs. You can access our branch office Web sites from the Worldwide Offices section of `ni.com`. Branch office Web sites provide up-to-date contact information, support phone numbers, e-mail addresses, and current events.

If you have searched the technical support resources on our Web site and still cannot find the answers you need, contact your local office or National Instruments corporate. Phone numbers for our worldwide offices are listed at the front of this manual.

# Glossary

| Prefix | Meanings | Value |
|---|---|---|
| µ- | micro- | $10^{-6}$ |
| m- | milli- | $10^{-3}$ |
| c- | centi- | $10^{-2}$ |
| k- | kilo- | $10^{3}$ |
| M- | mega- | $10^{6}$ |

## Numbers/Symbols

| | |
|---|---|
| ° | degrees |
| % | percent |
| ± | plus or minus |
| + | positive of, or plus |
| – | negative of, or minus |
| / | per |
| Ω | ohm |
| +5 V | +5 VDC source signal |

## A

| | |
|---|---|
| A | amperes |
| absolute mode | treat the target position loaded as position relative to zero while making a move |
| absolute position | signal position relative to zero |
| active-high | a signal is active when its value goes high (1) |
| active-low | a signal is active when its value goes low (0) |

| | |
|---|---|
| A/D | analog-to-digital |
| address | character code that identifies a specific location (or series of locations) in memory |
| amplifier | the drive that delivers power to operate the motor in response to low level control signals. In general, the amplifier is designed to operate with a particular motor type—you cannot use a stepper drive to operate a DC brush motor, for instance |
| anticipation time breakpoint | used to pre-load a desired anticipation time relative to the end of a programmed motion trajectory—when the position corresponding to the desired anticipation time is reached, an external breakpoint signal transitions on a dedicated I/O port output line for the selected axis. The anticipation breakpoint function is similar to, and shares the same resources as, the position breakpoint function. |
| API | application programming interface |
| axis | unit that controls a motor or any similar device |
| axis <1..4> Dir (CCW) | stepper—axis 1 through 4 motor direction or counter-clockwise control |
| Axis <1..4> Encoder Phase A | closed-loop—axis 1 through 4 phase A encoder input |
| Axis <1..4> Encoder Phase B | closed-loop—axis 1 through 4 phase B encoder input |
| Axis <1..4> Forward Limit | axis 1 through 4 forward/clockwise limit switch |
| Axis <1..4> Home Switch | axis 1 through 4 home switch |
| Axis <1..4> $\overline{\text{Inhibit}}$ | stepper—axis 1 through 4 drive inhibit |
| Axis <1..4> Reverse Limit | axis 1 through 4 reverse/counter-clockwise limit switch |
| Axis <1..4> Step (CW) | stepper—axis 1 through 4 motor step or clockwise control |

## B

| | |
|---|---|
| b | bit—one binary digit, either 0 or 1 |
| base address | memory address that serves as the starting address for programmable registers. All other addresses are located by adding to the base address. |
| binary | a number system with a base of 2 |
| buffer | temporary storage for acquired or generated data (software) |
| bus | the group of conductors that interconnect individual circuitry in a computer. Typically, a bus is the expansion vehicle to which I/O or other devices are connected. |
| byte | eight related bits of data, an eight-bit binary number. Also used to denote the amount of memory required to store one byte of data. |

## C

| | |
|---|---|
| CCW | counter-clockwise—implies direction of rotation of the motor |
| CL | closed-loop—a broadly applied term relating to any system where output is measured and compared to input. The output is then adjusted to reach the desired condition. In motion control this term applies to a system using an encoder or any feedback device. |
| common | reference signal for digital I/O |
| CPU | central processing unit |
| crosstalk | an unwanted signal on one channel due to an input on a different channel |
| CW | clockwise—implies direction of motor rotation |

## D

| | |
|---|---|
| DC | direct current |
| dedicated | assigned to a particular function |
| DGND | digital ground signal |

| | |
|---|---|
| digital I/O port | a group of digital input/output signals |
| DIP | dual inline package |
| DLL | dynamic link library—provides the API for the controllers |
| drivers | software that controls a specific controller |

## E

| | |
|---|---|
| encoder | device that translates mechanical motion into electrical signals; used for monitoring position or velocity |
| encoder resolution | the number of encoder lines between consecutive encoder indexes (marker or Z-bit). If the encoder does not have an index output the encoder resolution can be referred to as lines per revolution. |

## F

| | |
|---|---|
| filtering | a type of signal conditioning that filters unwanted signals from the signal being measured |
| filter parameters | indicates the control loop parameter gains (PID gains) for a given axis |
| following error trip point | the difference between the instantaneous function trajectory position and the feedback position |
| freewheel | the condition of a motor when power is de-energized and the motor shaft is free to turn |
| full-step | full-step mode of a stepper motor—for a two phase motor this is done by energizing both windings or phases simultaneously |

## G

| | |
|---|---|
| Gnd | ground |
| GND | ground |

## H

| | |
|---|---|
| half-step | mode of a stepper motor—for a two phase motor this is done by alternately energizing two windings and then only one. In half step mode, alternate steps are strong and weak but there is significant improvement in low-speed smoothness over the full-step mode. |
| hex | hexadecimal |
| home switch (input) | a reference position in a motion control system derived from a mechanical datum or switch. Often designated as the zero position. |
| host computer | computer into which the motion controller is plugged |

## I

| | |
|---|---|
| ID | identification |
| in. | inches |
| index | marker between consecutive encoder revolutions |
| I/O | input/output—the transfer of data to and from a computer system involving communications channels, operator interface devices, and/or motion control interfaces |
| interlock | 5 V bus voltage monitoring circuitry present on accessories |
| inverting | the polarity of a switch (limit switch, home switch, etc.) in *active* state. If these switches are active-low they are said to have inverting polarity. |
| IRQ | interrupt request |

## K

| | |
|---|---|
| k | kilo—the standard metric prefix for 1,000, or $10^3$, used with units of measure such as volts, hertz, and meters |
| K | kilo—the prefix for 1,024, or $2^{10}$, used with B in quantifying data or computer memory |

## L

| | |
|---|---|
| latching | a signal that maintains its value while in a given state, as opposed to a signal that momentarily pulses when entering or exiting a state |
| limit switch (input) | sensors that alert the control electronics that physical end of travel is being approached and that the motion should stop |

## M

| | |
|---|---|
| m | meters |
| microstep | mode of a stepper motor—subdividing the basic motor step by proportioning the current in the windings. In this way the step size is reduced and low speed smoothness is dramatically improved |
| modulo position | treat the target position as within the range of total quadrature counts per revolution for an axis |

## N

| | |
|---|---|
| noise | an undesirable electrical signal—noise comes from external sources such as the AC power line, motors, generators, transformers, fluorescent lights, soldering irons, CRT displays, computers, electrical storms, welders, radio transmitters, and internal sources such as semiconductors, resistors, and capacitors. Noise corrupts signals you are trying to send or receive. |
| noninverting | the polarity of a switch (limit switch, home switch, etc.) in *active* state. If these switches are active-high, they are said to have non-inverting polarity. |

## O

| | |
|---|---|
| OL | open-loop—refers to a motion control system where no external sensors (feedback devices) are used to provide position or velocity correction signals |

## P

| | |
|---|---|
| PID | proportional-integral-derivative control loop |
| port | (1) a communications connection on a computer or a remote controller (2) a digital port, consisting eight lines of digital input and/or output |
| position breakpoint | position breakpoint for an encoder can be set in absolute or relative quadrature counts. When the encoder reaches a position breakpoint, the associated breakpoint output immediately transitions. |
| power cycling | turning the host computer off and then back on, which resets the controller |
| prestore | trigger buffer function storage, which stores a series of functions in a buffer. |
| pull-in move | when stepper motors are run in closed-loop mode, the encoder feedback is used to verify the position of an axis when the motion ends. The motion controller then functions the axis to do a final move so that it is at the desired target position. |
| PWM | Pulse Width Modulation—a method of controlling the average current in a motors phase windings by varying the on-time (duty cycle) of transistor switches |

## Q

| | |
|---|---|
| quadrature counts | the encoder line resolution times four |

## R

| | |
|---|---|
| RAM | random-access memory |
| relative breakpoint | sets the position breakpoint for an encoder in relative quadrature counts |
| relative mode | treat the target position loaded as position relative to current position while making a move |
| relative position | position relative to current position |
| ribbon cable | a flat cable in which the conductors are side by side |

| | |
|---|---|
| rotary axis | an axis for which rotary counts are loaded. The axis moves to the target position by taking the shortest path, either forward or backwards, while remaining within the one revolution defined by the loaded rotary counts. |
| RPM | revolutions per minute—units for velocity. |
| RPSPS or RPS/S | revolutions per second squared—units for acceleration and deceleration. |

## S

| | |
|---|---|
| s | seconds |
| stepper | specifies an axis that controls a stepper motor |

## T

| | |
|---|---|
| toggle | changing state from high to low, back to high, and so on |
| torque | force tending to produce rotation |
| trapezoidal profile | a typical motion trajectory, where a motor accelerates up to the programmed velocity using the programmed acceleration, traverses at the programmed velocity, then decelerates at the programmed acceleration to the target position |
| trigger | any event that causes or starts some form of data capture |
| TTL | transistor-transistor logic |

## V

| | |
|---|---|
| V | volts |
| $V_{CC}$ | positive voltage supply |
| velocity mode | move the axis continuously at the specified velocity |

## W

| | |
|---|---|
| watchdog | a timer task that shuts down (resets) the controller if any serious error occurs |
| word | the standard number of bits that a processor or memory manipulates at one time, typically 8-, 16-, or 32-bit |

## Z

| | |
|---|---|
| Z-bit | marker between consecutive encoder revolutions |

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